NASA-DoD Lead-Free Electronics Project

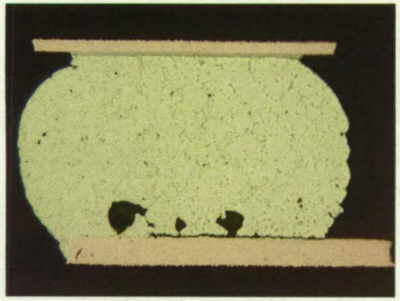
BAE SYSTEMS

COM DEV

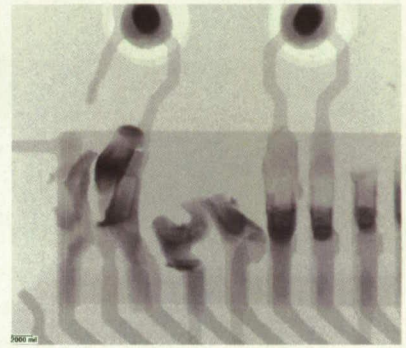
Rockwell Collins

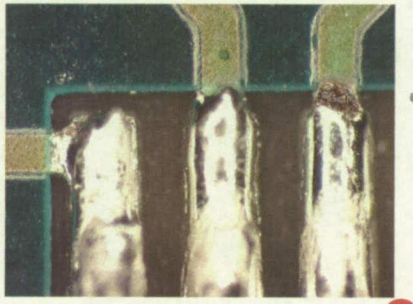
Raytheon

LOCKHEED MARTIN
We never forget who we're working for™



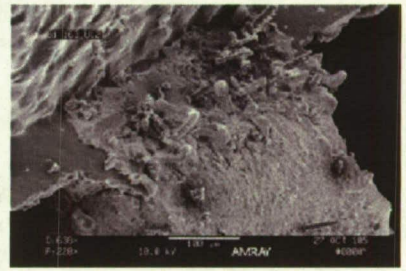
NASA





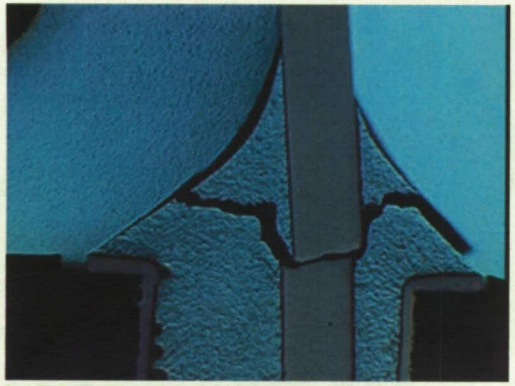
U.S. AIR FORCE

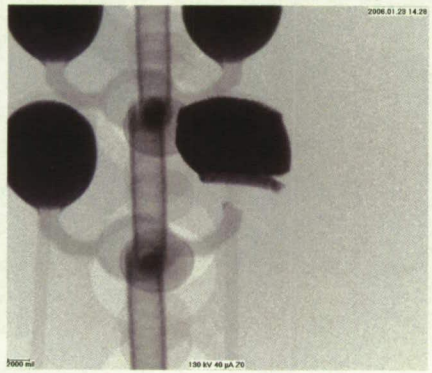
NAVSEA
WARFARE CENTERS
CRANE

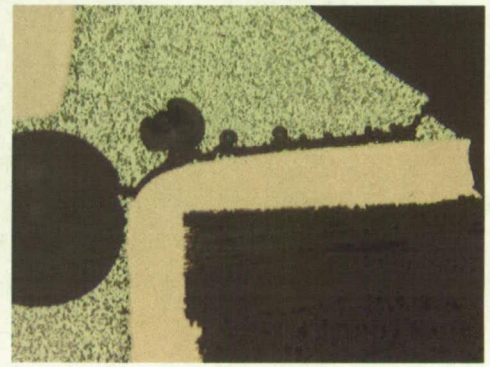


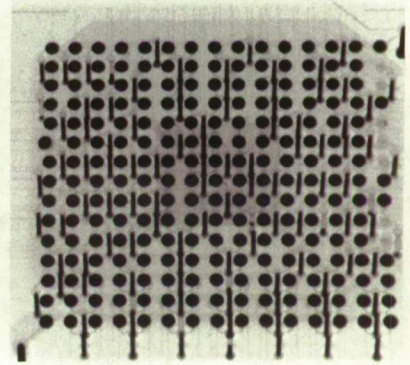
calce

ITB·inc.









Texas Instruments

BOEING

CELESTICA

HARRIS

TT APSCO

NASA-DoD Lead-Free Electronics Project

The primary technical objective of the project is to undertake comprehensive testing to generate information on failure modes/criteria to better understand the reliability of:

- Packages (e.g., TSOP, BGA, PDIP) assembled and reworked with lead-free alloys
- Packages (e.g., TSOP, BGA, PDIP) assembled and reworked with mixed (lead/lead-free) alloys

Web Link:

NASA-DoD Lead-Free Electronics Project:
http://acqp2.nasa.gov/projects/NASALeadFreeElectronics_Proj2.html

Comparison of NASA-DOD LFE Project to predecessor JCAA/JG-PP Project

- **Similarities**
  - Virtually identical test vehicle
  - Procedures identical for most tests
  - Same facility for assembly
  - SN100C being used for wave soldering

- **Differences**
  - Test articles will be thermally aged after assembly
  - Increased Rework
  - Increased solder mixing
  - Mechanical shock test procedure
  - Drop Testing
  - Immersion Ag surface finish for all test vehicles
  - SAC305 being used for reflow soldering
  - SN100C being used for reflow soldering

NASA-DoD Lead-Free Electronics Project Stakeholders

NAVSEA
WARFARE CENTERS
CRANE

DEFENSE MICROELECTRONICS ACTIVITY
UNITED STATES OF AMERICA

LOCKHEED MARTIN
We never forget who we're working for™

Rockwell Collins

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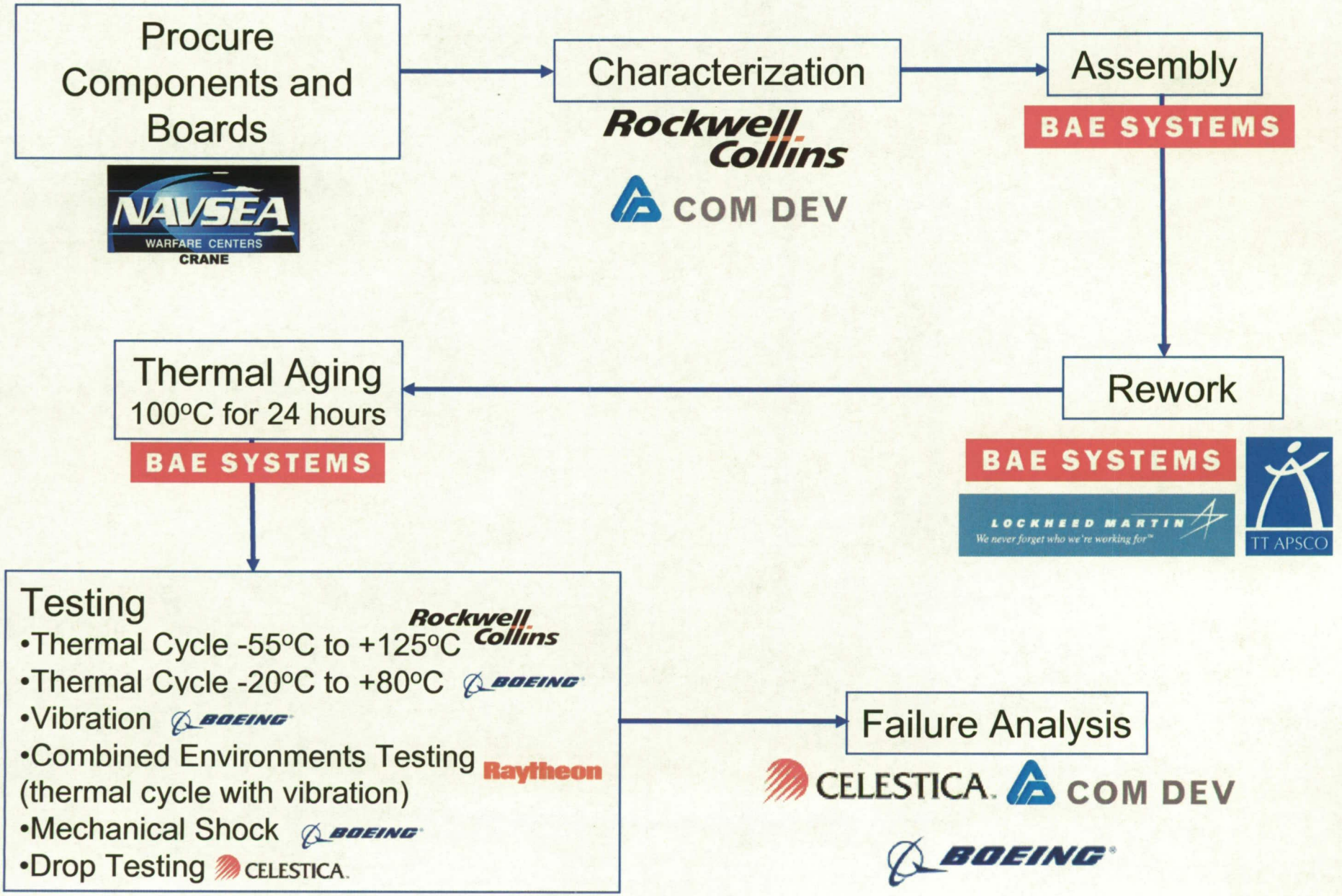
Project Flow



Lead-Free Solder Alloys

SAC305 (Sn3.0Ag0.5Cu)
– Surface mount assembly

This alloy was chosen for reflow soldering because this particular solder alloy has shown the most promise as a primary replacement for tin-lead solder. The team decided that they wanted to select at least one “general purpose” alloy to be evaluated and it was determined that the SnAgCu solder alloy would best serve this purpose.

SN100C (Sn0.7Cu0.05Ni+Ge)
– Plated through hole
– Surface mount assembly

This alloy is commercially available and the general trend in industry has been switching to the nickel stabilized tin-copper alloy over standard tin-copper due to superior performance. In addition, this nickel-stabilized alloy does not require special solder pots and has shown no joint failures in specimens with over 4 years of service.

Components & Component Finishes

Component	Component Finish	Note
CLCC	Au	Convert finish to SAC305; dipping lead to component body
CLCC	Au	Convert finish to SnPb; dipping lead to component body
QFN	Matte Tin	
QFN	SnPb	
TQFP - 144	NiPdAu	
TQFP - 144	Matte Tin	Convert finish to SAC305; dipping lead to component body
TQFP - 144	Matte Tin	Convert finish to SnPb; dipping lead to component body
BGA – 225	SAC405	
BGA – 225	SnPb	
DIP - 20	Matte Tin	
DIP - 20	NiPdAu	
CSP - 100	SAC105	
CSP - 100	SAC405	
CSP - 100	SnPb	
TSOP-50	SnBi	
TSOP-50	Matte Sn	

Test Vehicle Assemblies

4 Main Categories

- SnPb Manufactured
- Lead-Free Manufactured
- SnPb Rework
- Lead-Free Rework

Assembly Profiles

SnPb Manufactured Test Vehicles	
Surface Finish	**Immersion Ag**
Solder Alloy	
Reflow = SnPb	Wave = SnPb
Reflow Profile:	**Wave Profile:**
Preheat = ~ 120 seconds @140 183°C	Solder Pot Temperature = 250°C
Peak temperature = 225°C	Preheat Board T = 101°C
Time above reflow = 60-90 sec	Peak Temperature = 144°C
Ramp Rate = 2-3 °C/sec	Speed: 110 cm/min

Assembly Profiles

Lead-Free Manufactured Test Vehicles	
Surface Finish	Immersion Ag
Solder Alloy	
Reflow = SAC305	Wave = SN100C
Reflow Profile:	**Wave Profile:**
Preheat = 60-120 seconds @150-190°C	Solder Pot Temperature = 265°C
Peak temperature target = 243°C	Preheat Board T = 134°C
Reflow:~20 seconds above 230°C	Peak Temperature = 157°C
~30-90 seconds above 220°C	Speed: 90 cm/min
Solder Alloy	
Reflow = SN100C*	Wave = SN100C
Reflow Profile:	**Wave Profile:**
Preheat = 60-120 seconds @150-190°C	Solder Pot Temperature = 265°C
Peak temperature target = 243°C	Preheat Board T = 134°C
Reflow:~20 seconds above 230°C	Peak Temperature = 157°C
~30-90 seconds above 220°C	Speed: 90 cm/min
* = Limited number of test vehicles being built, 16	

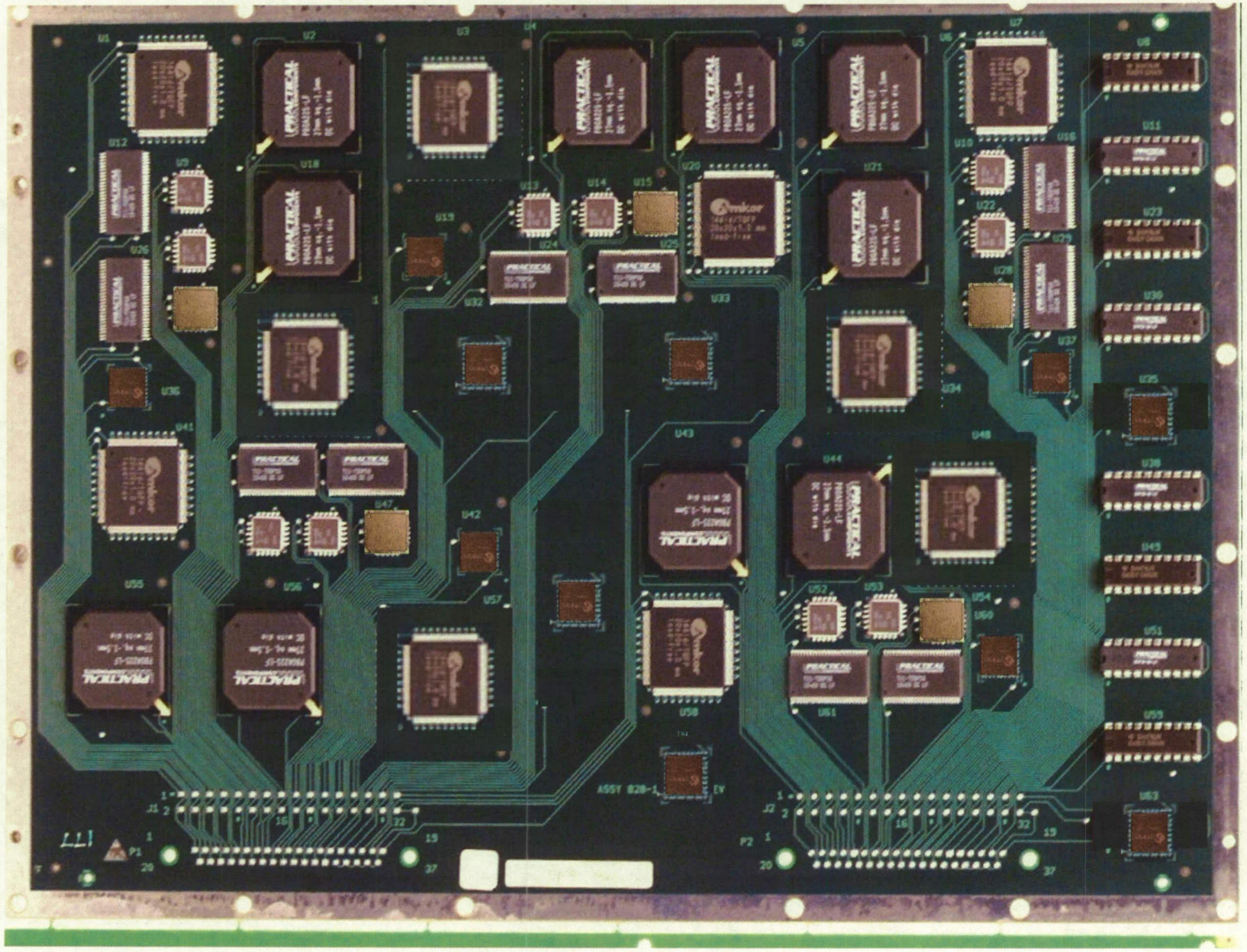
Assembly Profiles

SnPb Rework Test Vehicles	
Surface Finish	Immersion Ag
	ENIG*
Solder Alloy	
Reflow = SnPb	Wave = SnPb
Reflow Profile:	**Wave Profile:**
Preheat = 60-120 seconds @150-190°C	Solder Pot Temperature = 265°C
Peak temperature target = 243°C	Preheat Board T = 134°C
Reflow:~20 seconds above 230°C	Peak Temperature = 157°C
~30-90 seconds above 220°C	Speed: 90 cm/min
* = Limited number of test vehicles being built, 8	

Assembly Profiles

Lead-Free Rework Test Vehicles	
Surface Finish	Immersion Ag
Solder Alloy	
Reflow = SAC305	Wave = SN100C
Reflow Profile:	**Wave Profile:**
Preheat = 60-120 seconds @150-190°C	Solder Pot Temperature = 265°C
Peak temperature target = 243°C	Preheat Board T = 134°C
Reflow:~20 seconds above 230°C	Peak Temperature = 157°C
~30-90 seconds above 220°C	Speed: 90 cm/min

Test Vehicle



Manufactured Test Vehicles
Component Finish/Solder Combinations
Thermal Cycle & Combined Environments Testing

SnPb Manufactured			
Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy
BGA-225	SAC405	SnPb	
BGA-225	SnPb	SnPb	
CLCC-20	SAC305	SnPb	
CLCC-20	SnPb	SnPb	
CSP-100	SAC105	SnPb	
CSP-100	SnPb	SnPb	
PDIP-20	NiPdAu		SnPb
PDIP-20	Sn		SnPb
QFN	Matte Sn	SnPb	
TQFP-144	Matte Sn	SnPb	
TQFP-144	SnPb Dip	SnPb	
TSOP-50	SnBi	SnPb	
TSOP-50	SnPb	SnPb	

LF Manufactured			
Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy
BGA-225	SnPb	SAC305	
BGA-225	SAC405	SAC305	
CLCC-20	SnPb	SAC305	
CLCC-20	SAC305	SAC305	
CSP-100	SnPb	SAC305	
CSP-100	SAC105	SAC305	
PDIP-20	NiPdAu		SN100C
PDIP-20	Sn		SN100C
QFN	Matte Sn	SAC305	
TQFP-144	SnPb Dip	SAC305	
TQFP-144	Matte Sn	SAC305	
TSOP-50	SnPb	SAC305	
TSOP-50	SnBi	SAC305	

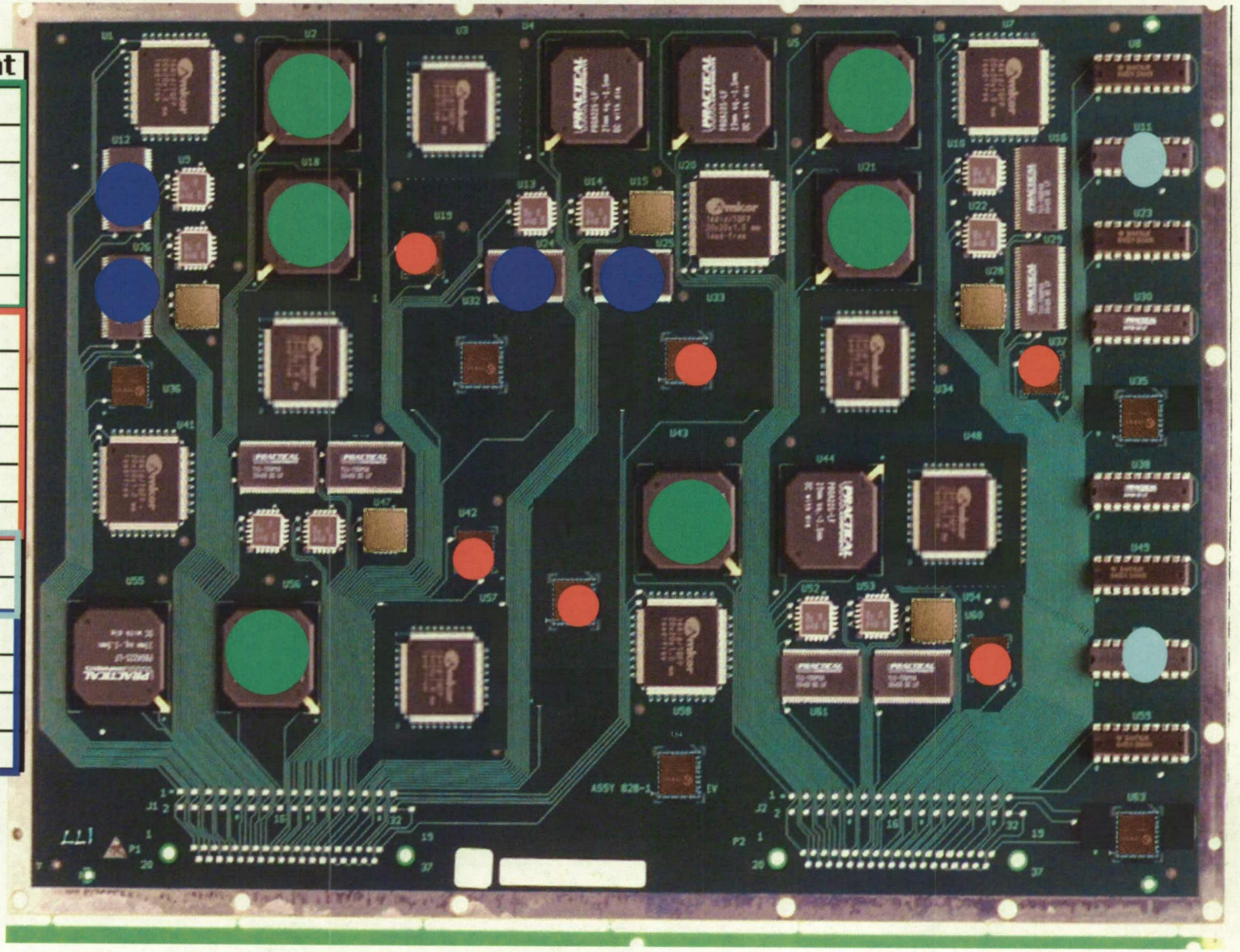
Manufactured Test Vehicles
Component Finish/Solder Combinations
Vibration and Mechanical Shock Testing

SnPb Manufactured			
Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy
BGA-225	SnPb	SnPb	
CLCC-20	SnPb	SnPb	
CSP-100	SnPb	SnPb	
PDIP-20	SnPb		SnPb
QFN	SnPb	SnPb	
TQFP-144	Matte Sn	SnPb	
TSOP-50	SnPb	SnPb	

LF Manufactured			
Component	Component Finish	Reflow Solder Alloy	Wave Solder Alloy
BGA-225	SAC405	SAC305	
CLCC-20	SAC305	SAC305	
CSP-100	SAC105	SAC305	
PDIP-20	Sn		SN100C
PDIP-20	NiPdAu		SN100C
QFN	Matte Sn	SAC305	
TQFP-144	Matte Sn	SAC305	
TSOP-50	SnBi	SAC305	
TSOP-50	Sn	SAC305	

Components to be Reworked

RefDes	Component
U18	BGA-225
U43	BGA-225
U06	BGA-225
U02	BGA-225
U21	BGA-225
U56	BGA-225
U33	CSP-100
U50	CSP-100
U19	CSP-100
U37	CSP-100
U42	CSP-100
U60	CSP-100
U11	PDIP-20
U51	PDIP-20
U12	TSOP-50
U25	TSOP-50
U24	TSOP-50
U26	TSOP-50



SnPb Rework Test Vehicles

SnPb Rework				
Component	**Original Component Finish**	**Original Solder Alloy**	**New Component Finish**	**Rework Solder**
BGA-225	SnPb	SnPb	SnPb	Flux Only
BGA-225	SAC405	SnPb		
BGA-225	SnPb	SnPb	SAC405	SnPb
CSP-100	SnPb	SnPb	SnPb	Flux Only
CSP-100	SAC105	SnPb		
CSP-100	SnPb	SnPb	SAC105	SnPb
TSOP-50	SnPb	SnPb	SnPb	SnPb
TSOP-50	Sn	SnPb		
TSOP-50	SnBi	SnPb		
TSOP-50	SnPb	SnPb	Sn	SnPb
PDIP-20	NiPdAu	SnPb		
PDIP-20	Sn	SnPb		
PDIP-20	SnPb	SnPb	Sn	SnPb

Lead-Free Rework Test Vehicles

Lead-Free Rework				
Component	**Original Component Finish**	**Original Solder Alloy**	**New Component Finish**	**Rework Solder**
BGA-225	SAC405	SAC305	SAC405	Flux Only
BGA-225	SnPb	SAC305		
BGA-225	SAC405	SAC305	SAC405	SnPb
CSP-100	SAC105	SAC305	SAC105	Flux Only
CSP-100	SnPb	SAC305		
CSP-100	SAC405	SAC305		
CSP-100	SAC105	SAC305	SAC105	SnPb
TSOP-50	SnBi	SAC305	SnBi	SAC305
TSOP-50	SnBi	SAC305		
TSOP-50	SnPb	SAC305		
TSOP-50	Sn	SAC305	Sn	SnPb
PDIP-20	Sn	SN100C		
PDIP-20	Sn	SN100C	Sn	SN100C

Rework Test Vehicles
Other Combinations

SnPb Rework		
Component	**Original Component Finish**	**Original Solder Alloy**
TQFP-144	SnPb Dip	SnPb
TQFP-144	NiPdAu	SnPb
CLCC-20	SAC305	SnPb

Lead-Free Rework		
Component	**Original Component Finish**	**Origianl Solder Alloy**
TQFP-144	SAC 305 Dip	SAC305
TQFP-144	NiPdAu	SAC305
CLCC-20	SnPb	SAC305

NASA/DoD Lead-Free Electronics Project

Project Activity	Performer	Number of Test Vehicles Required						Reference
		Manufactured			Rework			
		Mfg. SnPb	Mfg. LF	Mfg. LF SN100C	Rwk. SnPb	Rwk. SnPb (ENIG)	Rwk. LF	
		82			74			
Testing Prep								
PWA Assy & Rework	BAE Systems Apsco Lockheed Martin	33	33	16	33	8	33	--
Extra Boards	N/A	2	2	-	2	1	2	--
					Rework Completed by BAE Systems			
Component Characterization	Rockwell Collins	1	1	1	1	1	1	--
					Rework Completed by BAE Systems			
Testing								
Thermal Cycling: -55°C to +125°C 30 min. high temp dwell	Rockwell Collins	5	5	5	5	1	5	IPC-SM-785
					Rework Completed by Lockheed Martin			
Thermal Cycling: -20°C to +80°C 15 min. high temp dwell	Boeing	5	5	-	5	1	5	IPC-SM-785
					Rework Completed by Lockheed Martin			
Vibration	Boeing	5	5	5	5	1	5	MIL-STD-810F
					Rework Completed by BAE Systems			
Combined Environments Testing	Raytheon	5	5	5	5	1	5	MIL-STD-810F
					Rework Completed by BAE Systems			
Drop Testing	Celestica	5	5	-	5	1	5	JESD22-B110A
					Rework Completed by TT Apsco			
Mechanical Shock	Boeing	5	5	-	5	1	5	MIL-STD-810F
					Rework Completed by TT Apsco			
Post Test								
Failure Analysis	COM DEV Boeing Celestica	#?	#?	#?	#?	#?	#?	--

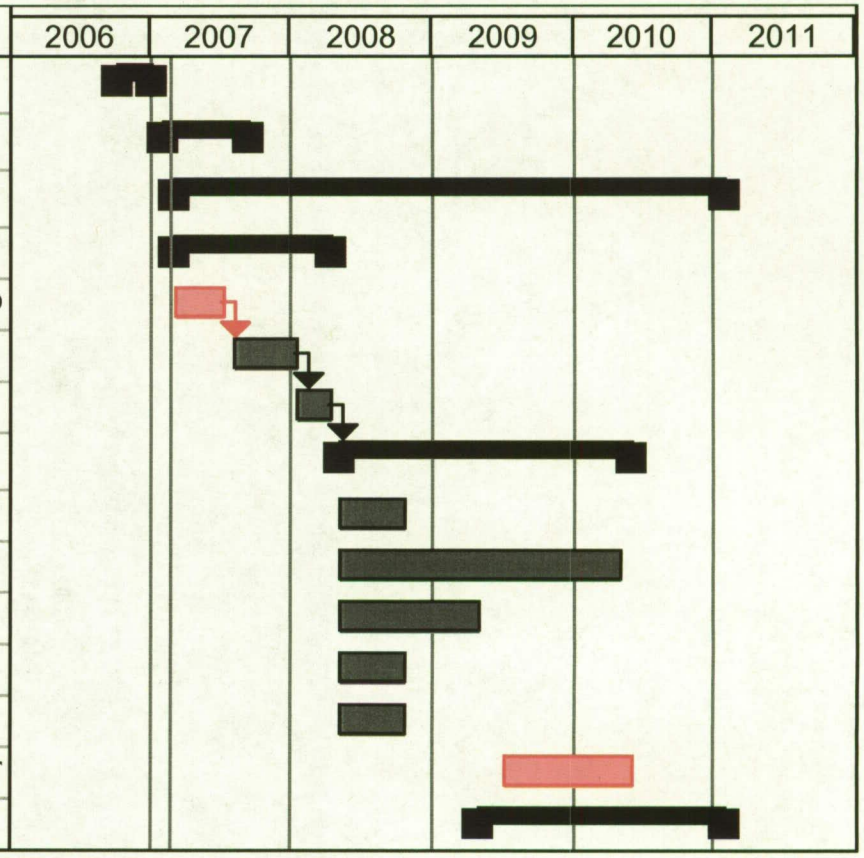
Project Funding

Project Activity		Performer	Funding Source	Estimated cost		
				Probable Direct Funding	**Probable** In-Kind Contribution	Funding **Shortfall**
				$345,000	**$504,000**	**$125,000**
Materials Procurement						
Component & Board Procurement		NAVSEA Crane (Gary Latta)	NAVSEA Crane		$100,000	
Solder Procurement		BAE Systems (Lety Campuzano-Contreras) Apsco (Marcus Wheeler)	*In-kind:* Solder suppliers Nihon Superior (Keith Sweatman)		$24,000	
PWA Assembly						
Surface Mount Assembly		BAE Systems (Lety Campuzano-Contreras)	*In-kind:* BAE Systems		$150,000	
Plated Through Hole Assembly		Apsco (Marcus Wheeler)	*In-kind:* Apsco			
Rework		BAE Systems (Lety Campuzano-Contreras) Apsco (Marcus Wheeler) Lockheed Martin (Linda Woody)	*In-kind:* BAE Systems Apsco Lockheed Martin			
Priority	**Testing**					
1	Thermal Cycling: -20°C to +80°C	Boeing (Tom Woodrow)	*In-kind:* Boeing Phantom Works		$80,000	
1	Thermal Cycling: -55°C to +125°C	Rockwell Collins (Dave Hillman)	NASA	$80,000		
2	Vibration	Boeing (Tom Woodrow)	DMEA	$125,000		
3	Combined Environments Testing	Raytheon (Jeff Bradford)	NASA	$125,000		
4	Drop Testing	Celestica (Polina Snugovsky)	DMEA	$15,000		
5	Mechanical Shock	Boeing (Tom Woodrow)	TBD			**$125,000**
Circuit Board Reliability Testing						
IST Testing		PWB Interconnect Solutions Inc (Bill Birch)	*In-Kind:* *PWB Interconnect Solutions Inc*		?	
Copper Dissolution, PTH		?	?		?	
Failure Analysis						
Failure Analysis		COM DEV (Jelena Bradic) Boeing (Anduin Touw) Celestica (Polina Snugovsky)	*In-kind:* COM DEV Boeing Celestica		$150,000	

Funding source needed!

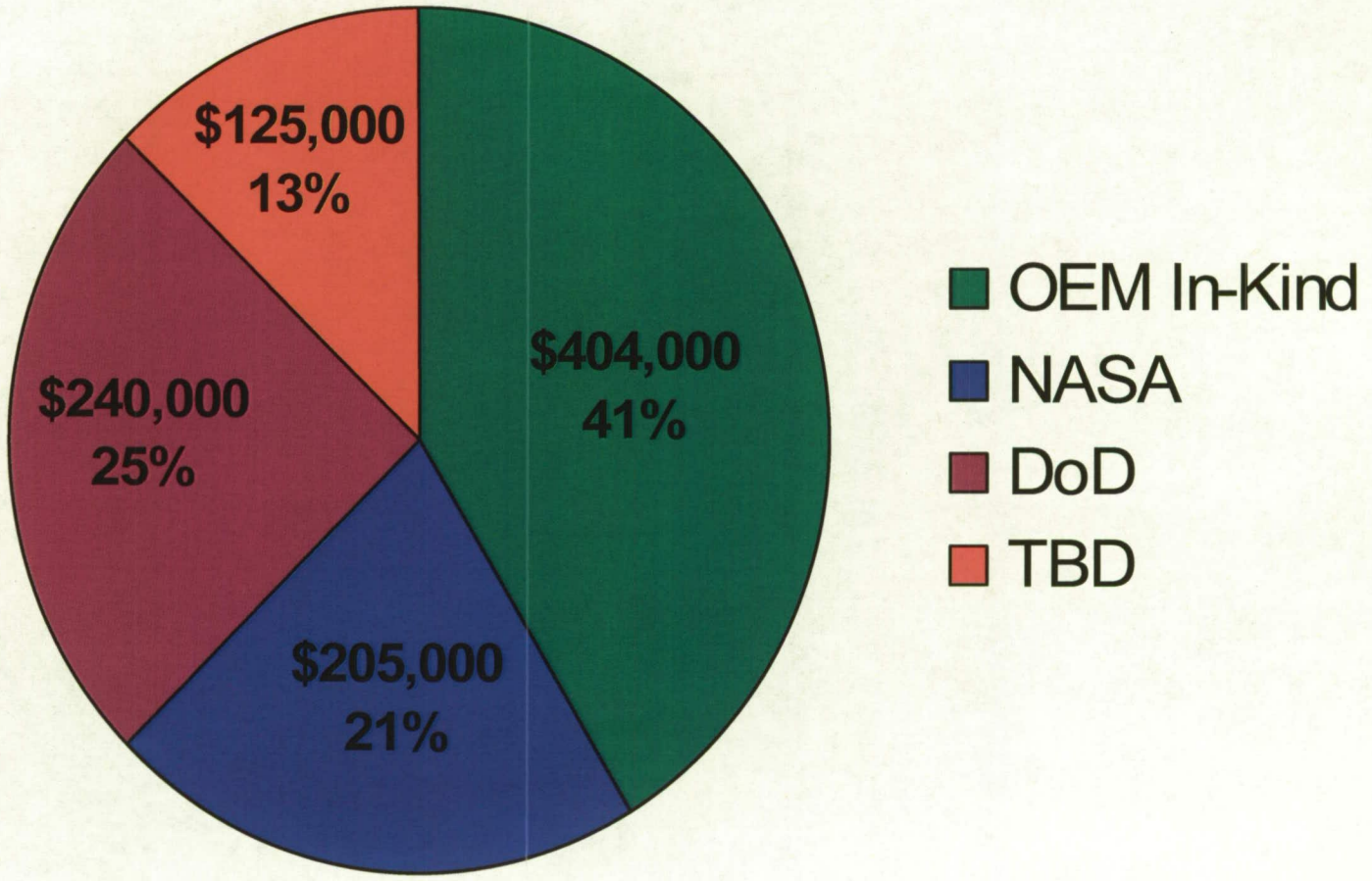
NASA-DoD LFE Project Schedule

Task Name
Identification Phase
Technical Phase
Demonstration/Validation Phase
Test Vehicle
Procure test vehicle materials (boards, components & so
Test vehicle build
Test vehilce set-up
Testing Phase
Vibration
Thermal Cycle -20/+80C
Thermal Cycle -55/+125C
Combined Environments Testing
Mechanical Shock
Failure Analysis? (timeframe will be based on completior
JTR

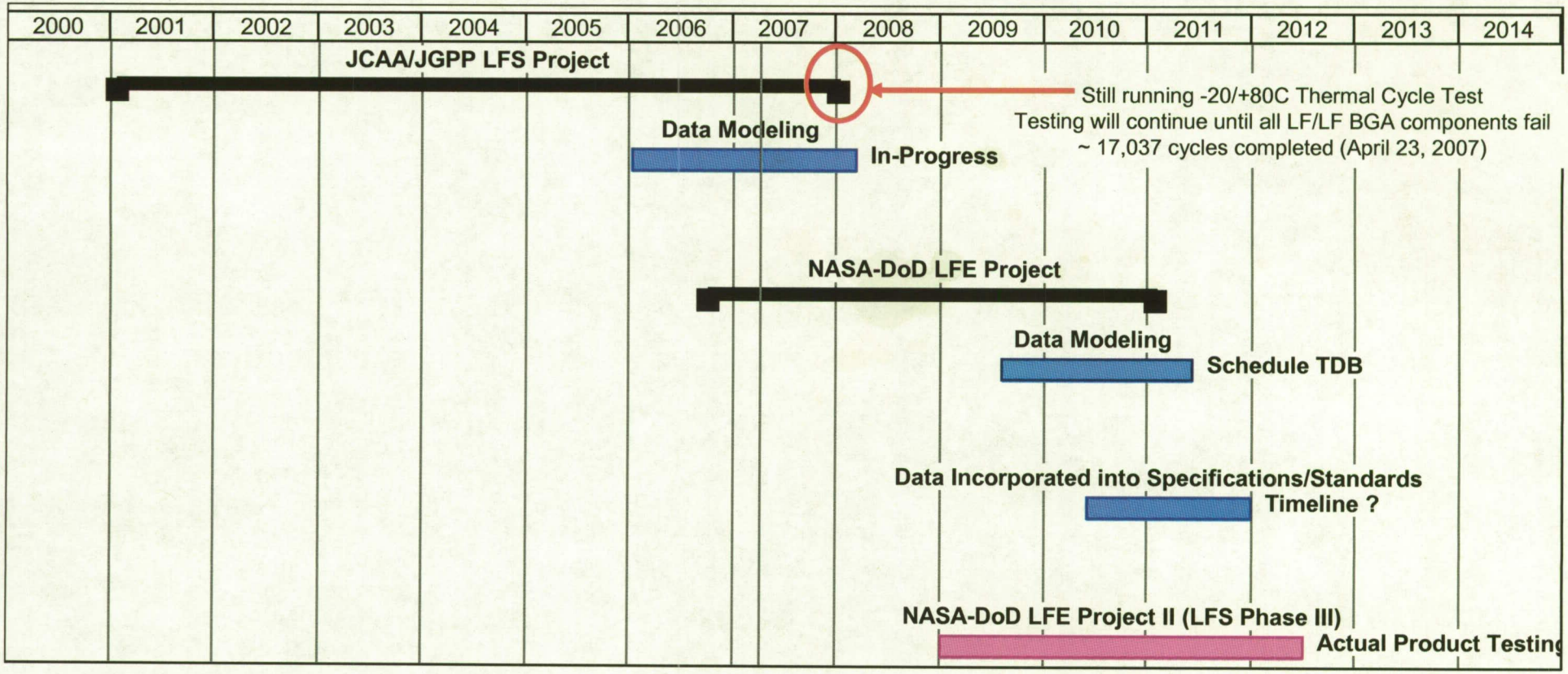


- Currently in the process of procuring components
- Circuit board details are being finalized, board procurement to follow

Contributions to the NASA-DoD Lead-Free Electronics Project



LF Projects Schedule



NASA-DoD Lead-Free Electronics Project

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Website: http://acqp2.nasa.gov

Web Links:

NASA-DoD Lead-Free Electronics Project:
http://acqp2.nasa.gov/projects/NASALeadFreeElectronics_Proj2.html

JCAA/JGPP Lead-Free Solder Testing for High Reliability:
http://acqp2.nasa.gov/projects/LeadFreeSolderTestingForHighReliability_Proj1.html